Signals and Circuits

ENGR 35500

Kirchhoff's law

2-2 (Kirchhoff's Law)

Ulaby, Fawwaz T., and Maharbiz, Michael M., *Circuits*, 2nd Edition, National Technology and Science Press, 2013.

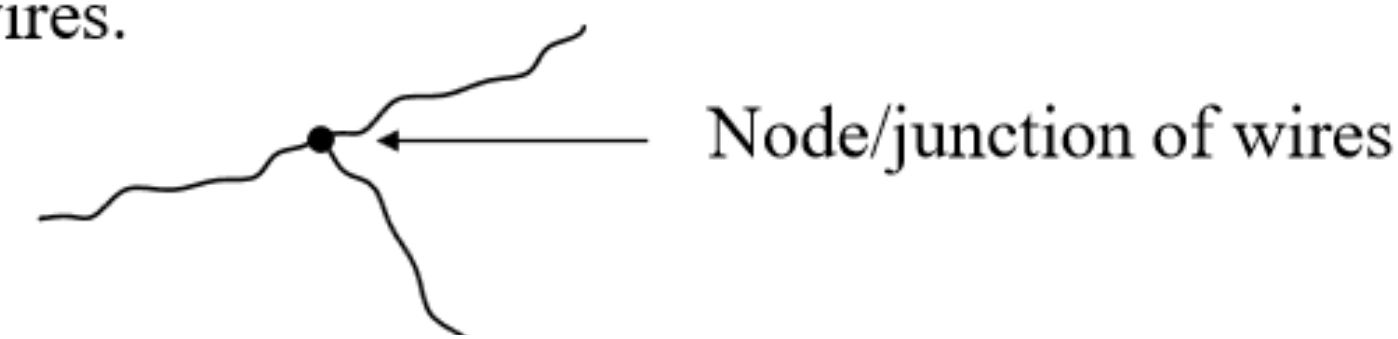
.

KENT STATE UNIVERSITY

Kirchhoff's Current Law (KCL)

- Conservation of charge implies that charge is neither created nor destroyed in electrical circuits.

- This principle leads directly to a constraint on the current at a junction (node) of wires.



- KCL: Because charge is conserved, the sum of currents (Algebraic sum of all currents) leaving (or entering) a node is zero at all times.

$$\sum_{k=1}^{n} I_k = 0$$

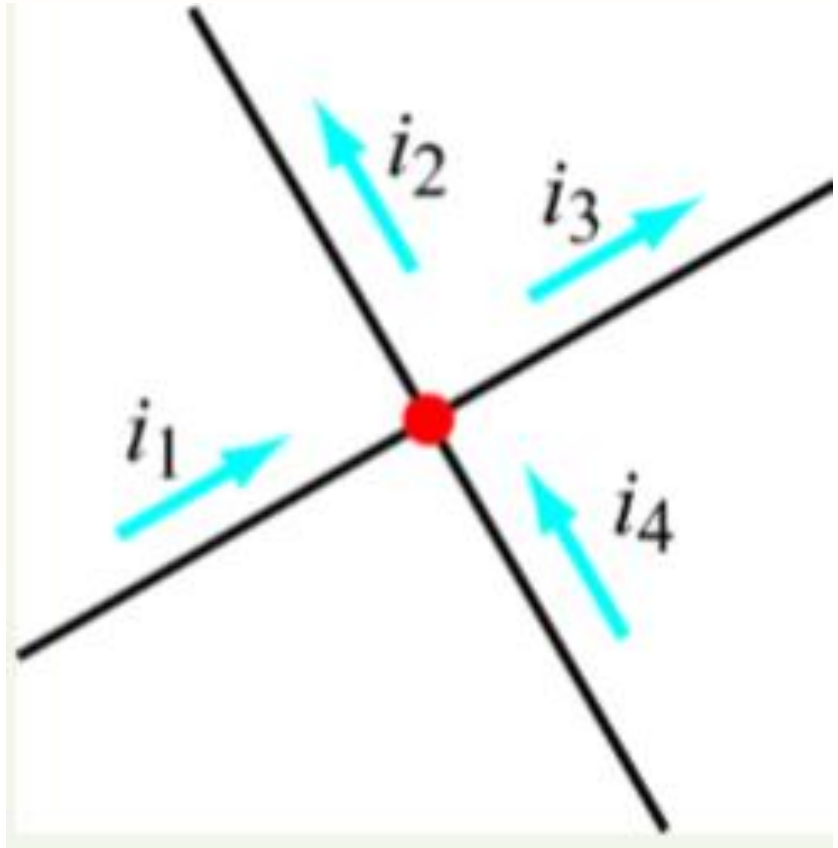
KENT STATE UNIVERSITY

Kirchhoff's Current Law (KCL)

A Common convention is to assign a positive "+" sign to a current if it entering the node and a negative "-" sign if it is leaving it.

$$i_1 - i_2 - i_3 + i_4 = 0$$

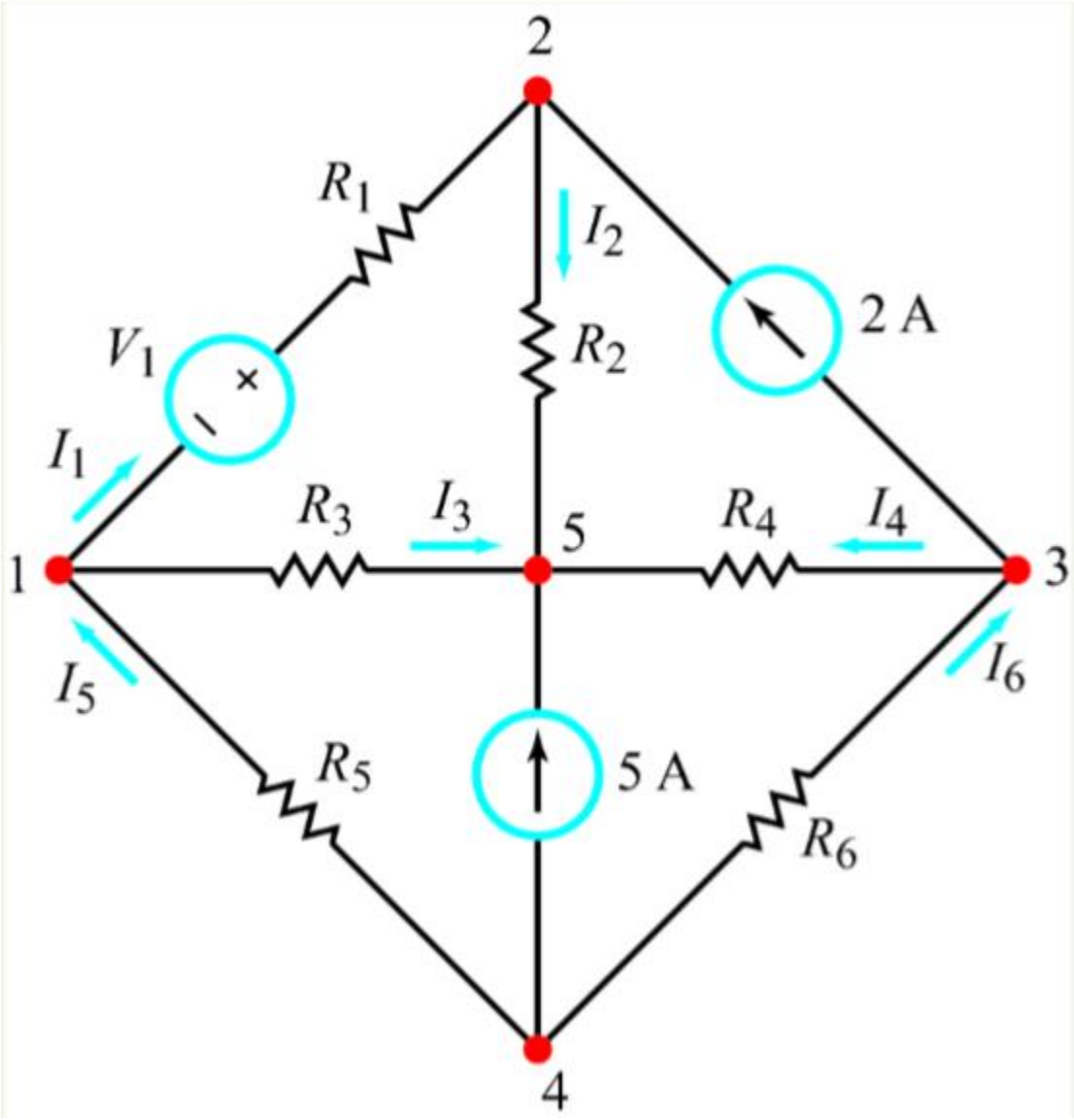
$$i_1 + i_4 = i_2 + i_3$$



KENT STATE UNIVERSITY

Kirchhoff's Current Law (KCL)

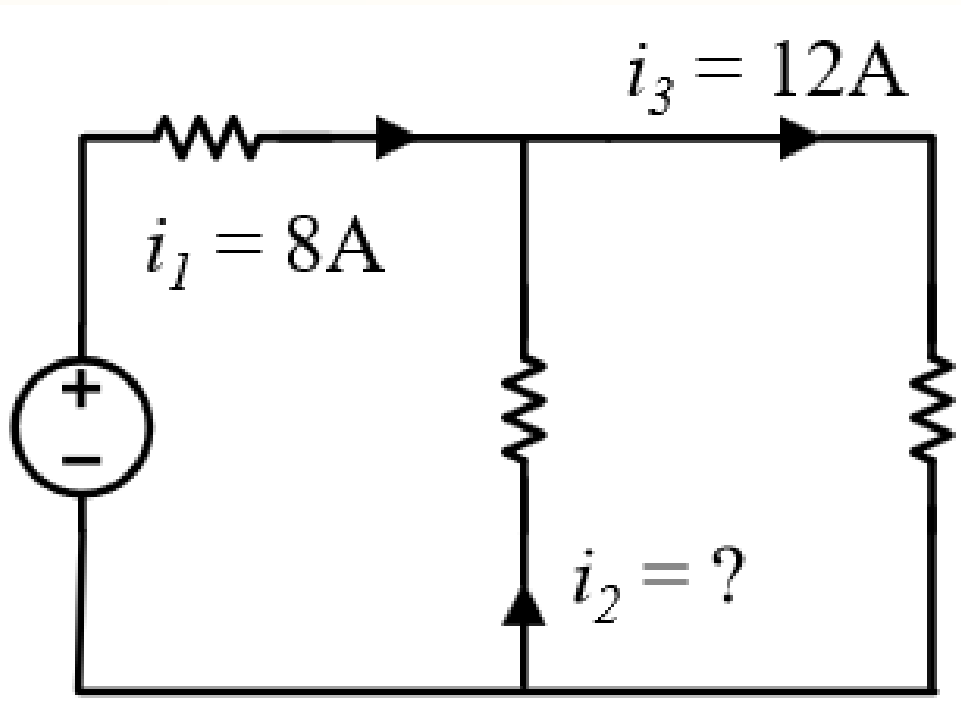
Write the KCL equations at nodes 1 through 5 in the circuit.



KENT STATE UNIVERSITY

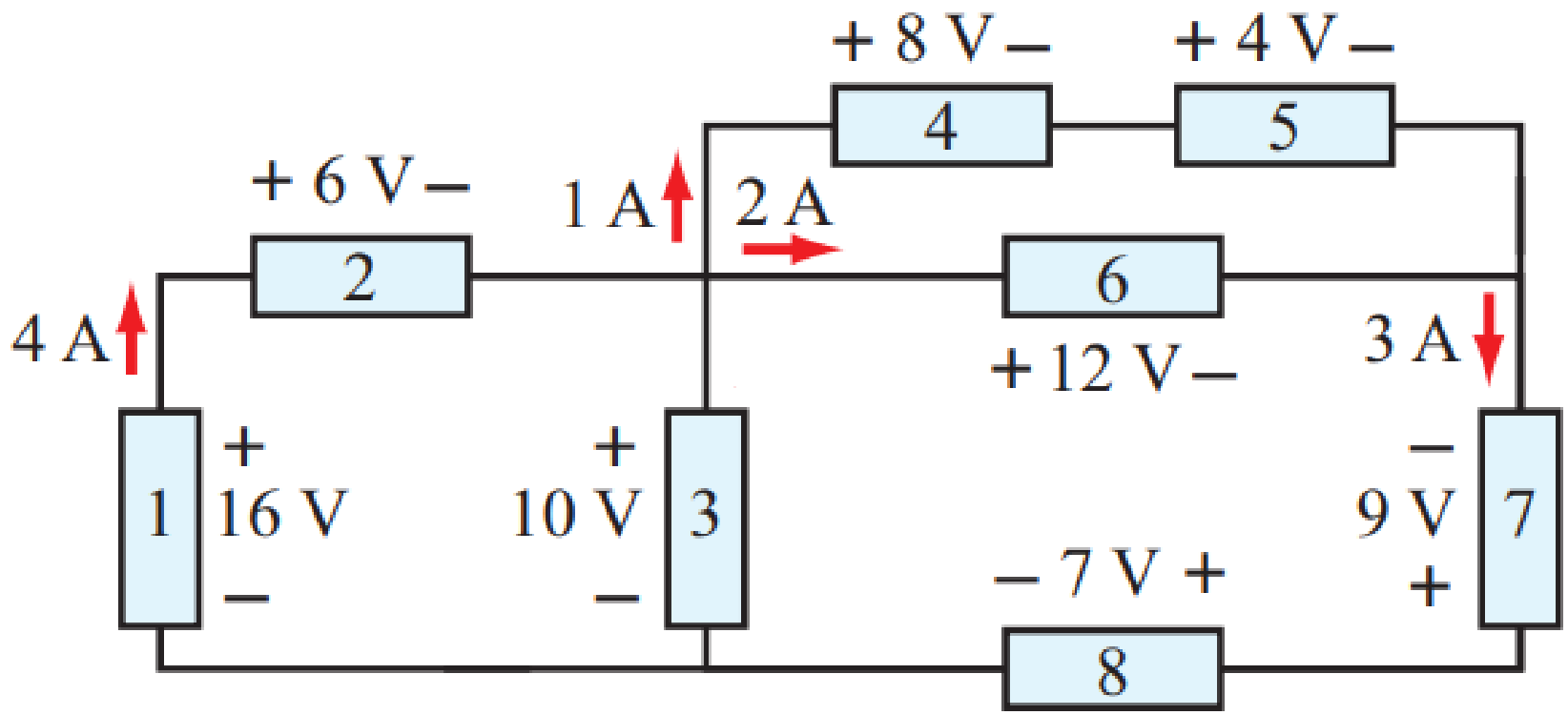
Kirchhoff's Current Law (KCL)

Example: Find i_2



Kirchhoff's Current Law (KCL)

Conservation of Power VS KCL



KENT STATE UNIVERSITY

Kirchhoff's Voltage Law (KVL)

The law of conservation of energy mandates that if we move electric charge around a closed loop, starting and ending at exactly the same location, the net gain or loss of energy must be zero.

The algebraic sum of the voltages around a closed loop must always be zero.

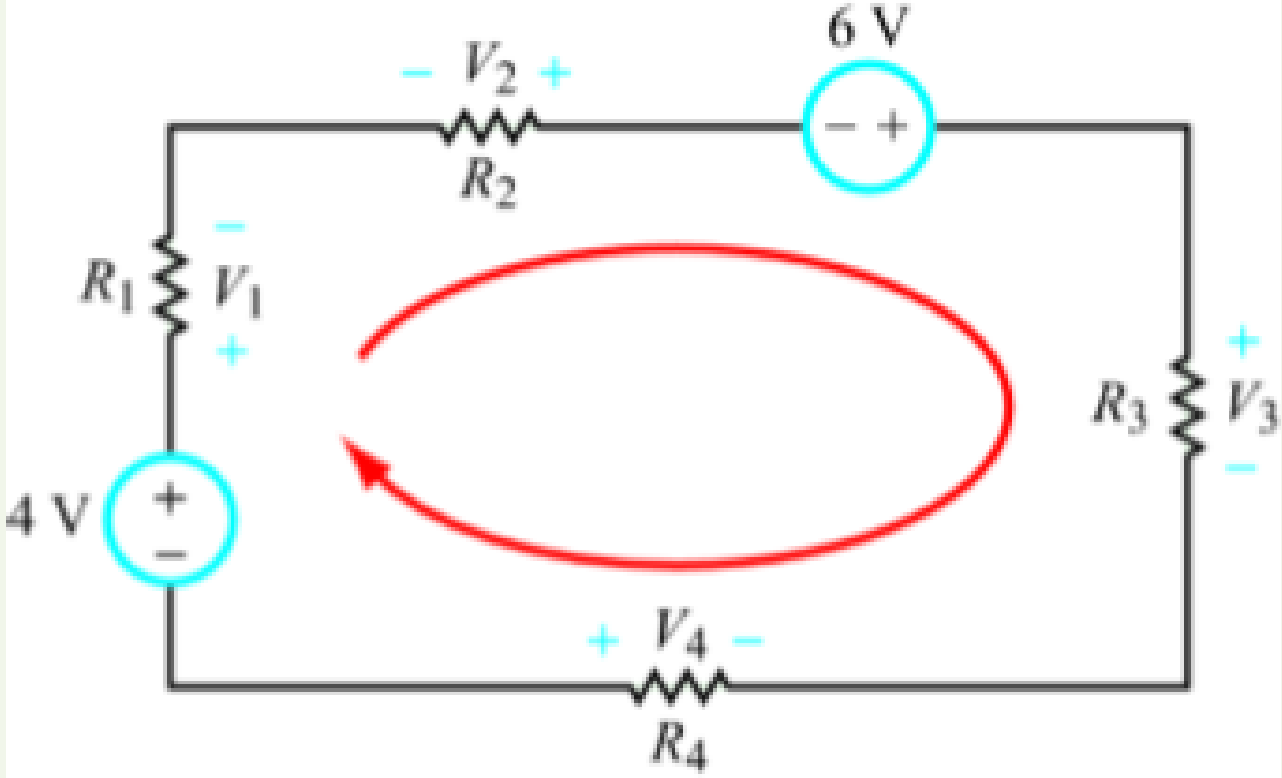
$$\sum_{n=1}^{N} v_n = 0 \qquad (KVL)$$

Kirchhoff's Voltage Law (KVL)

Sign Convention

Add up the voltages in a systemic clockwise movement around the loop.

Assign a positive sign to the voltage across an element if the (+) side of that voltage is encountered fist, and assign a negative sign if the (-) side is encountered first.



$$-4 + V_1 - V_2 - 6 + V_3 - V_4 = 0$$

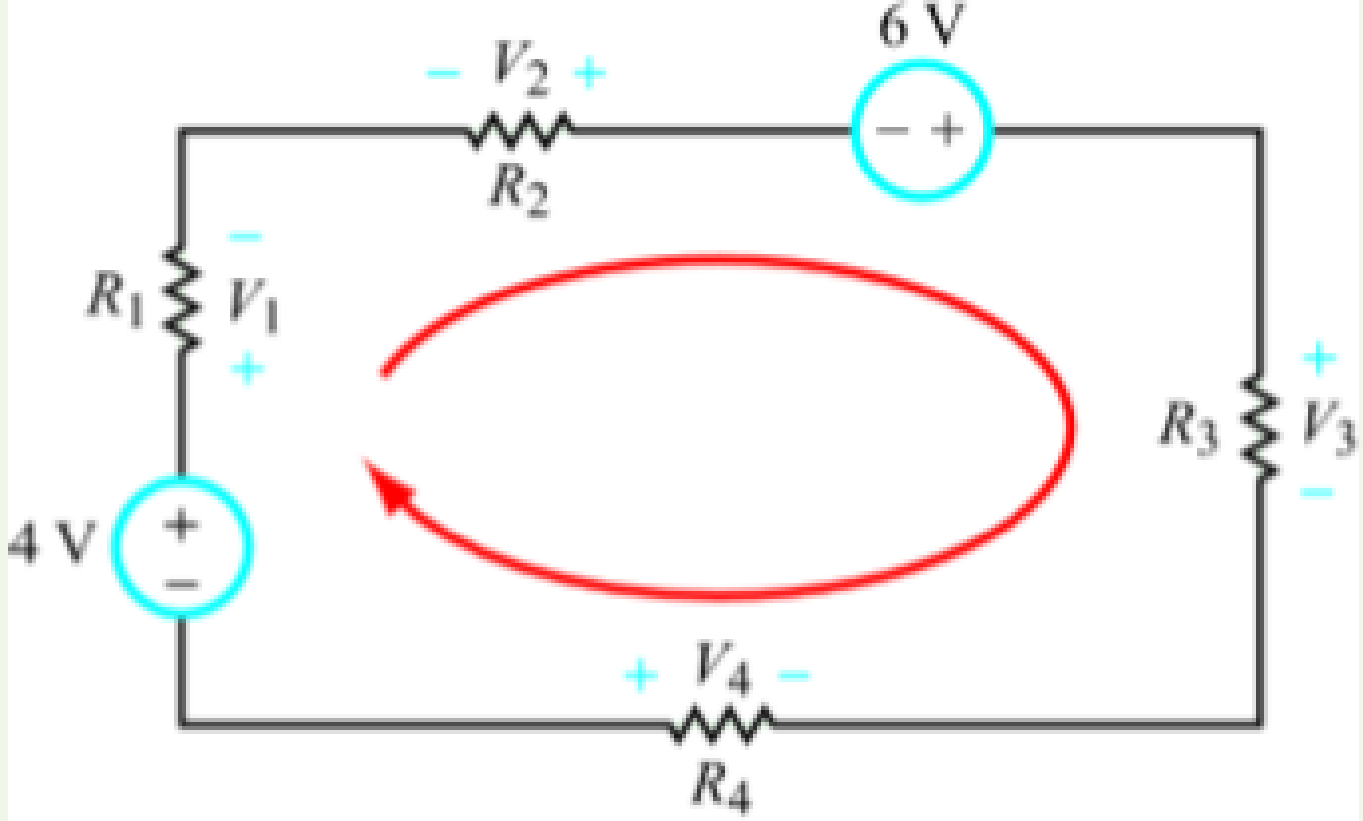
KENT STATE UNIVERSITY

Kirchhoff's Voltage Law (KVL)

Sign Convention

Add up the voltages in a systemic clockwise movement around the loop.

Alternative statement of KVL is that the total voltage rise around a closed loop must equal the total voltage drop around the loop.

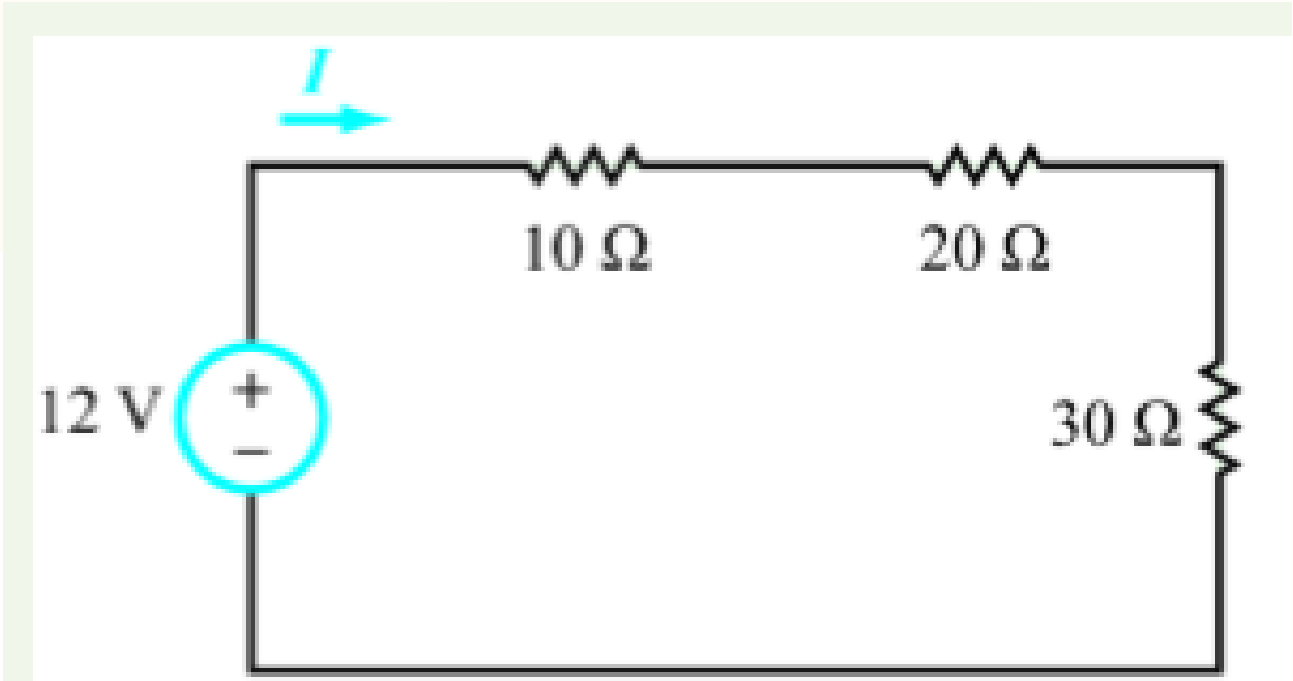


$$4 + V_2 + 6 + V_4 = V_1 + V_3$$

KENT STATE UNIVERSITY

Kirchhoff's Voltage Law (KVL)

Determinate the value of current ***I*** in the circuit.

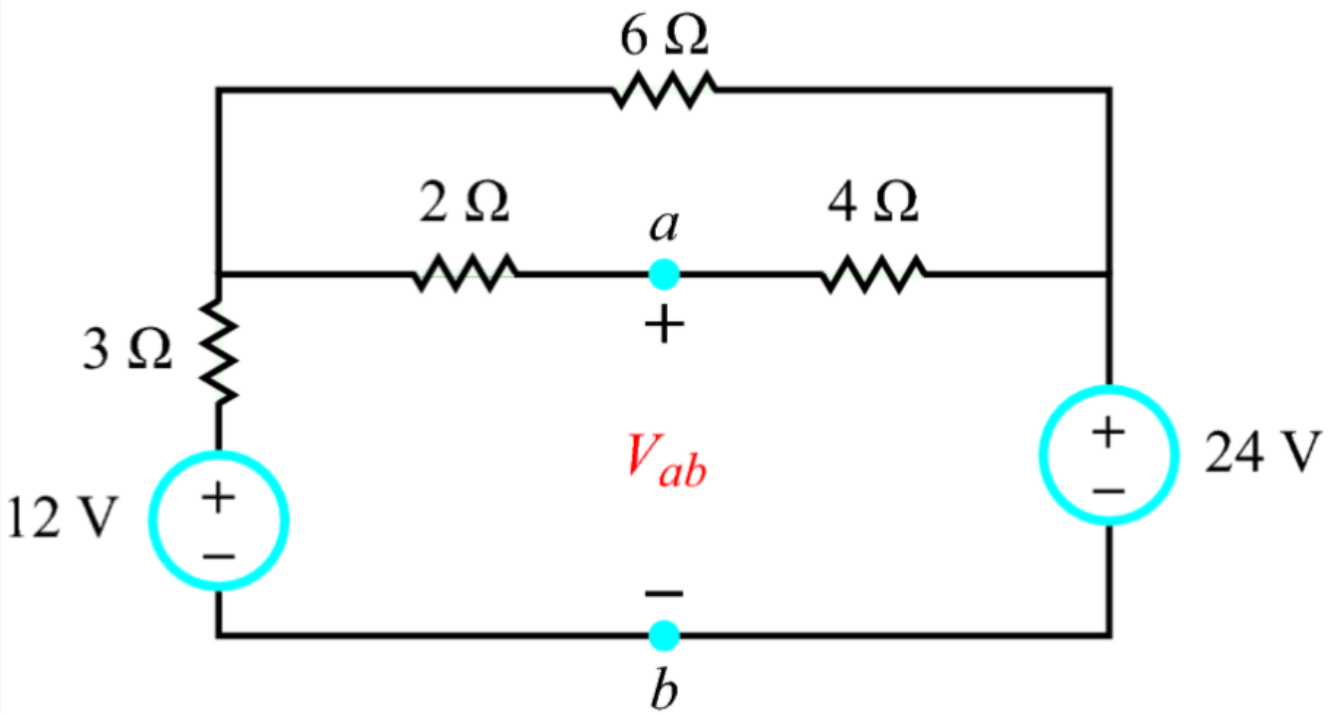


KENT STATE UNIVERSITY

Kirchhoff's Law

Determinate

a. The current through each of the other resistors;
b. The voltage of V_{ab};
c. The power delivered to the circuit by the battery on the right.



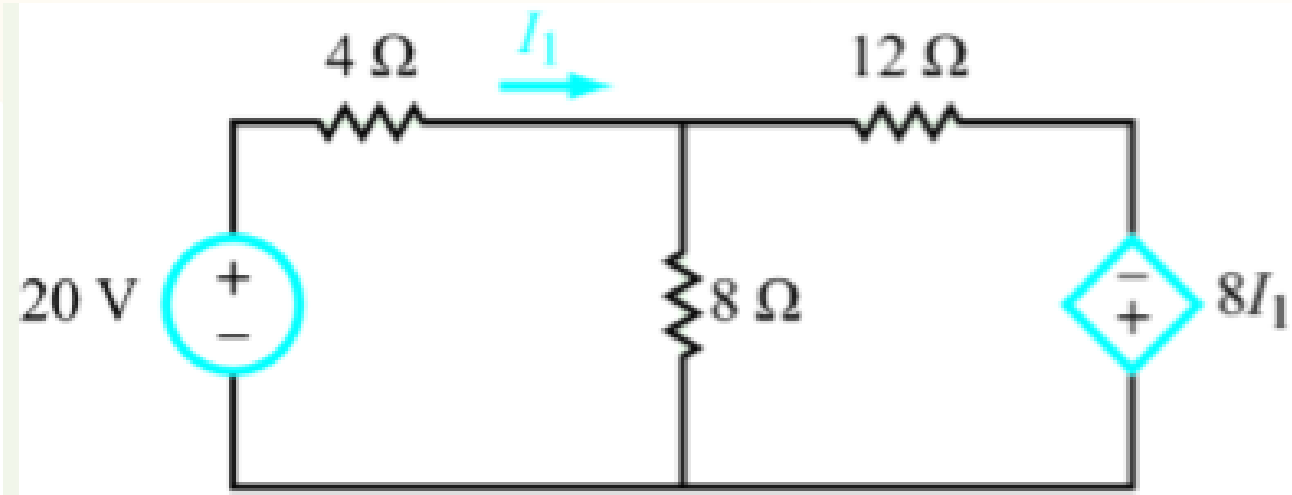
Steps:

1. Labels
2. Distinguish loops
3. KVL
4. Ohm's law
5. KCL
6. Simultaneous solution of equations

KENT STATE UNIVERSITY

Kirchhoff's Law

Determinate the amount of power consumed by the 12 Ω resistor.



Steps:

1. Labels
2. Distinguish loops
3. KVL
4. Ohm's law
5. KCL
6. Simultaneous solution of equations

KENT STATE UNIVERSITY